

# An Improved Technic for Vascular Isolation of the Liver:

## Experimental Study and Case Reports

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IN AN earlier communication,<sup>11</sup> on the right thoracoabdominal approach to the liver, it was suggested that the inferior vena cava could be controlled between the liver and the diaphragm as well as below the liver. This approach has been widely accepted.<sup>2, 4, 6, 9, 12-14, 22, 24-26</sup>

To avoid cumbersome division of the costal margin and entry into the pleural space, which the conventional thoracoabdominal incision involves, a new technic has been devised.

### Anatomic Studies

In fresh postmortem specimens it was found that the ligamentum teres, divided at the liver margin, could be used for downward traction of the liver and triangular ligament.

The bare area could thus be brought into view for dissection, starting antero-inferiorly and proceeding upward and backward over the dome of the liver (Fig. 1). The vena cava at that level could then be cross-clamped or encircled by tape.

It was found that isolation of the vena cava was easier in infants and increased in difficulty with age of the patient. Because of the difficulty encountered in older per-

sons an approach to the intrapericardial vena cava was designed (Fig. 2).

Within the pericardium the inferior vena cava in most specimens is almost completely ensheathed by parietal pericardium; the attachment suggests a dorsal mesentery. This is the same site at which the inferior vena cava is encircled to ensnare the inferior venous catheter during extracorporeal circulation.

A curved transverse incision in the tendinous portion of the diaphragm anterior to the vena cava best exposed the intrapericardial inferior vena cava for clamping or tape encirclement. The vein can be

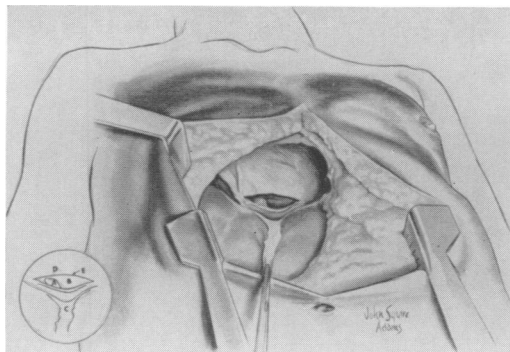


FIG. 1. Artist drawing at post mortem: A. intrapericardial vena cava, B. base of heart seen through opening, C. cut border of triangular ligament, D. diaphragm, E. anterior lip of transverse opening.

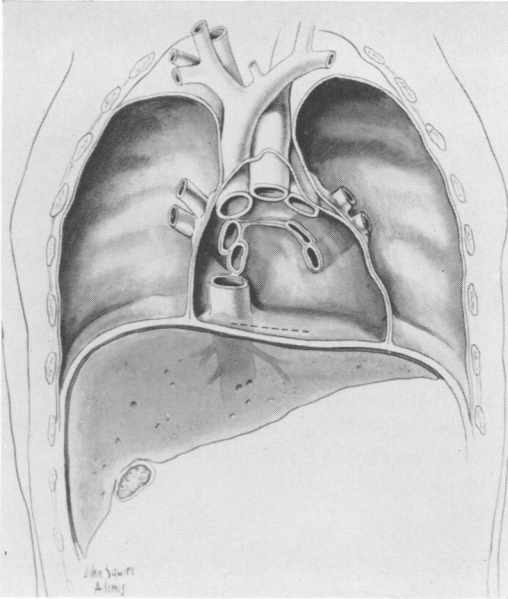


FIG. 2. Artist drawing from post mortem. Dotted line indicates site of opening into pericardial space from above. Vena cava, near right end of the area is clearly demonstrated.

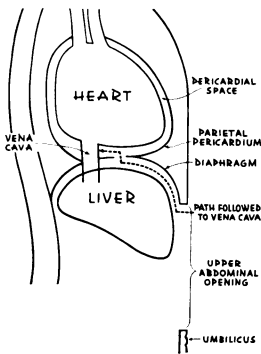


FIG. 3. Diagram of approach to the vena cava within the pericardium.

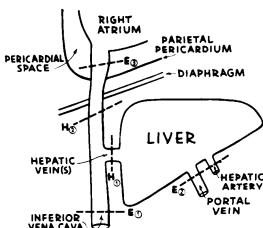


FIG. 4. Diagram of vascular connections. E<sub>1</sub>, E<sub>2</sub>, H<sub>1</sub>, H<sub>2</sub> are sites of occlusion. At H<sub>1</sub>, H<sub>2</sub>, vascular control is more difficult.

drawn forward by traction on the posterior lip of the incision in the diaphragm. The inferior surface of the heart can be retracted superiorly with a stockinette-covered, malleable retractor (Fig. 3).

The maneuver was easier at operation because of mobility of living tissues. The vena cava was either encircled or cross-clamped in an anteroposterior direction.

**Technic.** The liver could then be isolated in four steps:

1. Tape encirclement of portal vein, hepatic artery and bile duct as a unit.
2. Tape encirclement of the inferior vena cava below the liver, above the renal veins.
3. Control of the inferior vena cava above the liver, below the diaphragm in infants, intrapericardially in older patients (Fig. 4).
4. Cross-clamping of the aorta below the diaphragm to prevent loss of blood volume into the lower torso and extremities while return flow through the inferior vena cava is prevented.

In practice these steps should be carried out in 4, 1, 2, 3, sequence to prevent unnecessary loss from the upper torso circulation. The liver may then be transected with loss of only that blood contained within the viscus.

### Experimental Studies

From experience, it was estimated that 30 minutes should be ample time for control of vessels in hepatic transection; this period was arbitrarily chosen in experiments. Six healthy, normothermic *baboons* were anesthetized with parenteral anesthesia (Sernylan) and the vessels were clamped.\* Pulse, respiration and blood

\* The difference in baboon and human anatomy made it impossible to duplicate the human procedure exactly; however, the hemodynamic alterations were identical. These anatomic features will be described in detail in a treatise on baboon anatomy under preparation by personnel of the Southwest Foundation for Research and Education.



FIG. 5. Side view of Case 1 before operation. For 3 months there had been progressive abdominal enlargement.

pressure were monitored for a period of 30 minutes of vascular isolation of the liver and for brief control periods before and after the experiment.

Intravascular fluids were withheld as part of the protocol. Following cross-clamping of the aorta, blood pressure rose significantly and remained elevated until termination of the occlusion. After release of occluded vessels pressure returned to the pre-experimental level. In one of six animals there was a significant fall of arterial pressure which rose after intravenous infusion of 5 per cent glucose in saline. This fall in pressure occurred immediately after intravenous injection of additional anesthetic agent in a restless animal.

No resections were performed other than cholecystectomy in one animal found to have cholecystitis and cholelithiasis. All animals were returned in good health to the baboon colony.

### Clinical Experience

Three cases are reported to illustrate significant features. Information was also gained from operations on unresectable lesions during the same period.

**Case 1.** A 2 year and 3 months-old girl had been in poor health for 1½ years with vague signs and symptoms. Six months before admission she

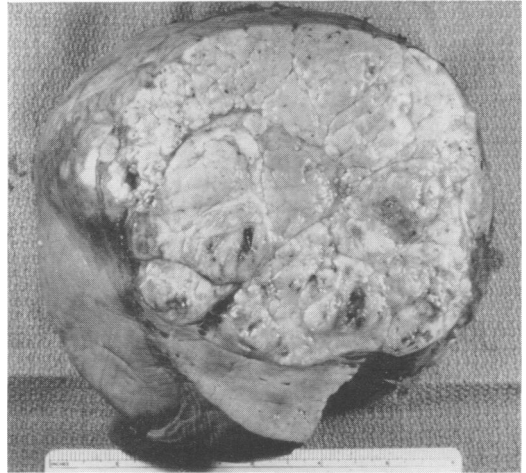


FIG. 6. Biopsy specimen from Case 1: carcinoma, hepatic cell type (hepatoma).

had inconstant, recurrent fever of unknown origin. For 3 months before admission there was progressive abdominal enlargement (Fig. 5).

On physical examination a large, palpable upper abdominal mass was presumed to be an hepatic neoplasm. At operation an enormous tumor occupied most of the right hepatic lobe, extended into the left lobe and produced marked distortion of the porta hepatis.

Through a right subcostal incision, four-step isolation of the vessels, as outlined above, was carried out. The inferior vena cava was isolated above the liver and below the diaphragm without opening pleural space or pericardium. The tumor was excised by sharp division; the vessels of the raw surface were readily seen and controlled by clamp and suture. Total vascular occlusion time was 20 minutes. The condition of the patient following operation was satisfactory.

Report of pathologist: The specimen consisted of a segment of liver which measured  $17 \times 16 \times 13$  cm. and weighed 1,400 Gm. The gallbladder was attached in anatomic position. Eighty per cent of the specimen was a reddish-brown carcinoma of the liver, hepatic cell type (hepatoma) (Fig. 6).

In several days jaundice developed and it became apparent that the biliary system of the left lobe had been compromised by the extensive resection. This led to the child's death 2 months later, following a second operation at which an attempt was made to secure an intrahepatic biliary radical for biliary-intestinal anastomosis. At post-mortem examination several minute metastatic foci were found in the lungs.

**Case 2.** A 70-year-old man had been hospitalized for 3 months with upper abdominal pain.

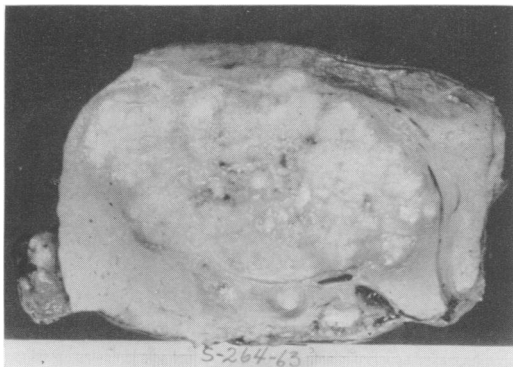


FIG. 7. Biopsy specimen from Case 3: metastatic adenocarcinoma from earlier colon lesion.

During the latter part of this period an epigastric mass was found.

For 4 years he had been admitted periodically for the same upper abdominal discomfort. At laparotomy a carcinoma (hepatoma) of the left lobe of the liver was encountered.

Through an upper midline abdominal incision, as outlined, the suprahepatic segment of the inferior vena cava was controlled intrapericardially. During operation hypotension developed which was puzzling since there was minimal bleeding in the operative field.

Vessels of the cut liver surface were clamped rapidly. Prior to abdominal closure the cause of hypotension became evident. In isolating the vena cava below the liver (and above the renal veins) the duodenum had been reflected and a small artery had been divided inadvertently. A large clot and much serosanguineous fluid were removed. Blood volume was restored and the postoperative course was favorable.

Although the patient improved for several weeks, rate of recovery then slowed and finally ceased with onset of ascites. He died 5 months following operation with ascites and recurrence (or persistence) of neoplasm in the liver.

At postmortem examination the incision in the diaphragmatic-pericardial wall was still open and measured 5 cm. in greatest dimension. There was free communication between the pericardial and abdominal spaces. Remaining right lobe of the liver weighed 975 Gm. and was markedly cirrhotic. Many microscopic areas showed infiltration by large tumor cells resembling those in the surgical specimen. No tumor was found beyond the liver.

**Case 3.** A 47-year-old woman was admitted with carcinoma of the transverse colon. Colectomy

was performed and followed by end-to-end reconstruction. Convalescence was uneventful.

One year later a mass appeared in the epigastrium which proved, on Rose Bengal scan, to be a nodule in the left lobe of the liver. The colon was normal; no metastases were evident elsewhere. Operation through an upper midline incision confirmed the diagnosis of metastasis to the left lobe of the liver which appeared to be solitary. The remainder of the liver, retroperitoneal nodes and other intra-abdominal structures were free of tumor.

The suprahepatic segment of the inferior vena cava was approached transdiaphragmatically and intrapericardially through a short transverse incision in the diaphragm. A moderate degree of pectus excavatum—which brought the posterior aspect of the sternum into proximity with the vertebral bodies—reduced the working space within the pericardium. Vascular isolation of the liver was accomplished. Circulation was occluded for 24 minutes. The specimen which measured  $12\frac{1}{2} \times 9 \times 7\frac{1}{2}$  cm. and weighed 260 Gm. was metastatic adenocarcinoma from the earlier colon lesion (Fig. 7).

The postoperative course was complicated by a too-secure closure of the pericardial opening which caused moderate pericardial tamponade. This was relieved by aspiration of serosanguineous fluid from the pericardial sac.

The patient later developed right pleural metastases and pleural effusion. She was treated with chemotherapeutic agents and at the present time, 2 years following hepatic resection and 3 years following colon resection, she is in good health and teaching school full-time.

### Comment

If difficulty is encountered in isolating the suprahepatic segment of the inferior vena cava, the pericardium should be entered without hesitation. Even in the 2-year-old child there was brief brisk bleeding from a minute hepatic vein which was inadvertently injured.

Traction downward and forward upon the posterior lip of the diaphragmatic incision delivers the intrapericardial segment of the inferior vena cava forward for easier isolation and control. This exposure is materially improved by traction upward on the inferior cardiac surface. The pericardial opening should not be closed too securely

as tamponade may be produced, and yet too lax closure may leave an aperture through which herniation can occur.<sup>23</sup>

### Summary

A technic is described for hepatic vascular control which is applicable in elective and emergency operations on the liver. The suprahepatic segment of the inferior vena cava is controlled below the diaphragm in infants and intrapericardially in older patients.

### Addendum

Since this paper was submitted two additional total right hepatic lobectomies have been carried out. One of these, in a 48 year old woman, was for carcinoma of the gall bladder. The second was for hepatoma in a 1½ year old boy. Convalescence in both patients was uneventful. In one patient there was a delayed complication when the common duct tube slipped out prematurely.

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